EXCERPT FROM:

BASELINE ECOLOGICAL RISK ASSESSMENT FOR THE INTERNATIONAL SMELTING & REFINING SITE TOOELE COUNTY, UTAH

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8 UNCERTAINTIES

Quantitative evaluation of ecological risks is generally limited by uncertainty regarding a number of important data. This lack of knowledge is usually circumvented by making estimates based on whatever limited data are available, or by making assumptions based on professional judgement when no reliable data are available. Because of these assumptions and estimates, the results of the risk calculations are themselves uncertain, and it is important for risk managers and the public to keep this in mind when interpreting the results of a risk assessment.

The following text summarizes the key sources of uncertainty influencing the results of this Baseline ERA.

8.1 Uncertainties in Nature and Extent of Contamination

8.1.1 Representativeness of Samples Collected

Concentration levels of chemicals in environmental media are often quite variable as a function of location, and may also vary significantly as a function of time. Thus, samples collected during a field sampling program may or may not fully characterize the spatial and temporal variability in actual concentration levels. At this site, field samples were collected in accord with sampling and analysis plans that specifically sought to ensure that samples were representative of the range of conditions across each exposure area. However, in some locations, the number of samples collected was relatively small. Thus, without the collection of very large numbers of samples over both space and time, some uncertainty remains as to whether the samples collected provide an accurate representation of the distribution of concentration values actually present.

8.1.2 Accuracy of Analytical Measurements

Laboratory analysis of environmental samples is subject to a number of technical difficulties, and values reported by the laboratory may not always be exactly correct. The magnitude of analytical error is usually small compared to other sources of uncertainty, although the relative uncertainty increases for results that are near the detection limit.

8.2 Uncertainties in Exposure Assessment

8.2.1 Pathways Not Evaluated

Exposure pathways selected for quantitative evaluation in this Baseline ERA do not include all potential exposure pathways for all ecological receptors. Exposure pathways that were not evaluated include:

- Ingestion of sediments and prey items by benthic invertebrates
- Dermal exposures of wildlife to soil, sediment and surface water
- Inhalation of dust particles by wildlife
- Ingestion of benthic invertebrates and small mammals by wildlife
- Exposures by amphibians and reptiles

Omission of these pathways will tend to lead to an underestimation of total risk to the exposed receptors. As discussed previously in Section 4, many of these exposure pathways (i.e., dermal exposures of wildlife) are likely to be minor compared to other pathways that were evaluated, and the magnitude of the underestimation is not likely to be significant in most cases. However, the exclusion of some exposure pathways may tend to underestimate predicted risks in some cases.

An example of this is ingestion of prey items by benthic invertebrates. Although the general consensus is that uptake of inorganic contaminants from food is usually less than from direct contact with water (Clements, 1991), available data are sufficient to indicate that the ingestion pathway can be an important source of exposure to some aquatic receptors (Timmermans et al., 1992), and that dietary exposures can be capable of limiting growth in at least some cases (Duddridge and Wainwright, 1980). Thus, omission of the ingestion pathway for aquatic receptors is likely to be a minor source of uncertainty in most cases, but could lead to an underestimate in some cases.

The exclusion of wildlife exposures via ingestion of benthic invertebrates and mammals may also lead to an underestimate of predicted risks in waterfowl and carnivorous wildlife. In addition, risks to amphibians and reptiles were not evaluated quantitatively in this Baseline ERA. The comparability of predicted risks for wildlife to those expected for amphibian and reptilian receptors is uncertain.

8.2.2 Chemicals Not Detected

Any chemical that was never detected in a site medium was not evaluated in exposures of receptors to that medium. However, in some cases, the analytical detection limit was too high to expect the chemical would have been detected even if it were present at the level of concern. COPC were selected in the SLERA (USEPA 2003a) and chemicals in this category were assigned as Type 2 Qualitative COPCs. Table 8-1 identifies the Type 2 Qualitative COPCs. Omission of these chemicals is likely to result in an underestimation of risk. However, it is suspected that the magnitude of the underestimation is likely to be low in most cases. This is because, if the non-detected chemical were actually site-related and were present at a level of substantial health concern, it likely would have occurred at levels above the detection limit at least a few times. Thus, while the hazard from Type 2 Qualitative COPCs is unknown, it is probably not large enough to cause a substantial underestimation of risk.

8.2.3 Exposure Area Concentration Values

In all exposure calculations, the desired input parameter is the true mean concentration of a chemical within a medium, averaged over the area where random exposure occurs. However, because the true mean cannot be calculated based on a limited set of measurements, the USEPA (1989, 1992) recommends that the exposure estimate be based on the 95% upper confidence limit (95UCL) of the statistic of interest. This approach is intended to ensure that exposure and risk estimates are likely to be conservative (i.e., overestimate risk). When data are plentiful and inter-sample variability is not large, the 95UCL may be only slightly higher than the statistic of interest, and the degree of overestimation may be minor. However, when data are sparse or are highly variable, the 95UCL may be far greater than the statistic of interest, and the degree of uncertainty and the extent of overestimation may be substantial.

In the wildlife receptor risk characterization, the exposure area concentration value depends upon the desired level of confidence (best estimate, upper bound) and the type of receptor (average, high end). The use of the upper 95UCL on the mean or the 90^{th} percentile of the concentration distribution helps ensure that HQ estimates Types C and D are more likely to be high than low, especially when data are sparse or highly variable. The difference between the best estimate and the upper bound estimate of HQ for a CTE or RME receptor (HQ Type A vs. B, Type C vs. D) is a good indication of the magnitude of the uncertainty associated with the exposure area concentration value for each chemical of potential concern.

8.2.4 Wildlife Exposure Factors

The intake (ingestion) rates for food, soil, and sediment used to estimate exposure of wildlife at the site are derived from literature reports of intake rates, body weights, dietary compositions, consumption rates, and metabolic rates in receptors at other locations or from measurements of laboratory-raised organisms. These values may or may not serve as appropriate models for site-specific intake rates of average (CTE) and upper-end (RME) wild receptors at this site. Moreover, the actual dietary composition of an organism will vary daily and seasonally. In addition, some wildlife receptor-specific intake rates are estimated by extrapolation from data on a closely related species or by use of allometric scaling equations (scaling of intake rates based on body weights). This introduces further uncertainty into the exposure and risk estimates. These uncertainties could either under- or overestimate the actual exposures of wildlife to chemicals in soil, sediment, and diet.

For this analysis, it was also assumed that wildlife exposures were continuous and that receptor home ranges were located entirely within the IS&R site (i.e., all of the total dietary intake was from the site). In the case of resident small-home range receptors, these assumptions are likely to be fairly realistic. However, these assumptions may tend to overestimate exposures in receptors that have a large home range and that may not be exposed on-site most of the time.

8.2.5 Absorption From Ingested Doses

The toxicity of an ingested chemical depends on how much of the chemical is absorbed from the gastrointestinal tract into the body. However, the actual extent of chemical absorption from ingested media (soil, sediment, food, and water) is usually not known. The hazard from an ingested dose is estimated by comparing the dose to an ingested dose that is believed to be safe, based on tests in a laboratory setting. Thus, if the absorption is the same in the laboratory test and the exposure in the field, then the prediction of hazard will be accurate. However, if the absorption of chemical from the site medium is different (usually lower) than occurred in the laboratory study, then the hazard estimate will be incorrect (usually too high). In this assessment, estimates of wildlife exposure assumed a relative bioavailability (RBA) of 100% for all chemicals in all media. This assumption is expected to be reasonable for chemicals in surface water and most dietary food items, but may tend to overestimate exposure for exposure to chemicals in soil and sediment. This is because metals in soil and sediment may occur in mineral phases that have low solubility, and this tends to reduce the amount of metal that is absorbed when ingested.

8.3 Uncertainties in Toxicity Assessment

8.3.1 Representativeness of Receptors Evaluated

Risk characterizations for aquatic receptors were based toxicity values which included a generalized set of species found in freshwater aquatic communities. However, not all of these species (e.g., fish) are expected to occur in waters at the IS&R site. Thus, HQ values above 1 may reflect risks to species that are absent at the site, and risks to species that are actually present at the site may be lower.

Risks to wildlife were assessed for a small subset of the species likely to be present at the IS&R site. Although the representative wildlife receptors selected represent a range of taxonomic groups and life history types of species likely to occur in the area, these species may not represent the full range of sensitivities present. The species selected may be either more or less sensitive to chemical exposures than typical species located within the area.

8.3.2 Absence of Toxicity Data for Some Chemicals

For a number of chemicals that were detected in one or more samples of site media, no reliable toxicity benchmark could be located for one or more receptor types. COPC were selected in the SLERA (USEPA 2003a) and chemicals in this category were assigned as Type 1 Qualitative COPCs. Table 8-1 identifies the Type 1 Qualitative COPCs. The inability to evaluate hazard from these chemicals is expected to result in an underestimation of risk, but it is suspected that the magnitude of the error is usually likely to be low. This is because the absence of a toxicity benchmark for a chemical is most often because toxicological concern over that chemical is low. That is, chemicals that lack benchmarks are often considered to be relatively less hazardous that those for which benchmarks do exist. To the extent that this is true (even though there are likely some exceptions to this rule), risks from Type 1 Qualitative COPCs are likely not to contribute risks of the same magnitude as those predicted for chemicals that do have a benchmark value.

8.3.3 Extrapolation of Toxicity Data Between Receptors

Toxicity data are not available for all of the species of potential concern at the site. Thus, it is sometimes necessary to estimate toxicity values for a receptor by extrapolating toxicity data across similar species. At this site, this extrapolation was direct: that is, no uncertainty factor was used to adjust a benchmark form one species when applied to another. This approach may either overestimate or underestimate the risk to the actual receptor, depending on whether the actual receptor is less sensitive or more sensitive that the species for which data are available,

and the magnitude of the error could be significant in some cases.

8.3.4 Extrapolation of Toxicity Data Across Dose or Duration

In some cases, TRV data are available only for high dose exposures, and extrapolation to low doses (similar to those that actually occur at the site) is a source of uncertainty. Likewise, some TRVs are based on relatively short-term exposures, and extrapolation to long-term exposures is uncertain, especially for chemicals that tend to build up in the exposed organism. When such extrapolations are necessary, it is customary to include one or more "uncertainty factors" in the derivation of the benchmark to account for the extrapolation. In general, these "uncertainty factors" are likely to be somewhat too large, so the benchmarks derived in this way are more likely to overestimate than underestimate true risk.

8.3.5 Extrapolation of Toxicity Data from Laboratory to Field Conditions

Even when toxicity data are available for a receptor of concern at the site, the data are usually generated under laboratory conditions, and extrapolation of those data to free-living receptors in the field is uncertain. One factor is that laboratory organisms are more homogeneous that wild populations. For example, laboratory test populations are usually all the same genetic strain, age, and gender, and all are usually healthy. In contrast, wild populations are genetically diverse, consist of individuals of different ages and genders, and health status may vary widely between individuals. In addition, laboratory animals are generally free from the stresses experienced by a wild population. Because of these factors, extrapolation of dose-response data and toxicity factors from laboratory species to wild populations is uncertain.. The magnitude and direction of error introduced by this extrapolation is unknown. However, greater variability in response to a chemical toxicant in wild populations that laboratory species is expected to result in an underestimation of risk to RME individuals in a population.

8.4 Uncertainties in Risk Characterization

8.4.1 Interactions Among Chemicals

Most toxicity benchmark values are derived from studies of the adverse effects of a single contaminant. However, exposures to ecological receptors usually involve multiple contaminants, raising the possibility that synergistic or antagonistic interactions might occur. However, data are generally not adequate to permit any quantitative adjustment in toxicity values or risk calculations based on inter-chemical interactions. In accordance with USEPA guidance, effects from different chemicals are not added unless reliable data are available to indicate that

the two (or more) chemicals act on the same target tissue by the same mode of action. At this site, HQ values for each chemical were not added across different chemicals. If any of the chemicals of concern at the site act by a similar mode of action, total risks could be higher than estimated. Conversely, if the chemicals of concern at the site act antagonistically, total risks could be lower than estimated.

8.4.2 Estimation of Population-Level Impacts

Assessment endpoints for the receptors at this site are based on the sustainability of exposed populations, and risks to some individuals in a population may be acceptable if the population is expected to remain healthy and stable. However, even if it is possible to accurately characterize the distribution of risks or effects across the members of the exposed population, estimating the impact of those effects on the population is generally difficult and uncertain. The relationship between adverse effects on individuals and effects on the population is complex, depending on the demographic and life history characteristics of the receptor being considered as well as the nature, magnitude and frequency of the chemical stresses and associated adverse effects. Thus, the actual risks that will lead to population-level adverse effects will vary from receptor to receptor.

8.5 Summary of Uncertainties

Table 8-2 summarizes the various sources of uncertainty in this Baseline ERA, along with a qualitative estimate of the direction and magnitude of the likely errors attributable to the uncertainty. Based on all of these considerations, the HQ and Total HQ values calculated and presented in this Baseline ERA should be viewed as having substantial uncertainty. Because of the inherent conservatism in the derivation of many of the exposure estimates and toxicity benchmarks, these HQ and Total HQ values should generally be viewed as being more likely to be high than low, and results and conclusions should be interpreted accordingly.

Table 8-2
Summary of Uncertainties in the Baseline Ecological Risk Assessment

Baseline Ecological Risk Assessment for the International Smelting & Refining Site

Assessment Component	Uncertainty Description	Likely Direction of Error	Likely Magnitude of Error
Nature and Extent of Contamination	Samples collected may not be fully representative of variability in space or time, especially if the number of samples is small.	Unknown	Probably small
	Analytical results may be imprecise.	Unknown	Probably small
Exposure Assessment	Some exposure pathways were not evaluated.	Underestimate of risk	Unknown, could be significant
	Some chemicals were not evaluated because chemical was never detected, but detection limit was too high to detect the chemical if it were present at a level of concern.	Underestimate of risk	Usually small
	Exposure point concentrations for wildlife receptors are based on a limited measured dataset.	Use of UCL or max detect is likely to overestimate risk	Variable (depends on number of data points and magnitude of variability); can be evaluated by comparing best estimate to upper bound estimate
	Exposure parameters for wildlife receptors are based on studies at other sites.	Unknown	Probably small
	Absorption from site media is assumed to be the same as in laboratory studies.	Overestimate of risks	Possibly significant
Toxicity Assessment	Wildlife receptors selected as representative species may not capture the full range of sensitivities in site receptors.	Unknown	Probably small
	Aquatic toxicity benchmarks are based on a wide range of species, some of which do not occur at this site.	Likely to overestimate risk	Probably small
	Many chemicals lack reliable toxicity benchmarks for some receptors for some media; these chemicals are not evaluated.	Underestimation of risk	Probably small in most cases
	Available toxicity benchmarks are often based on limited data, and values must be extrapolated across species.	Unknown	Unknown, could be significant

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Toxicity Assessment (cont.)	Available toxicity benchmarks are often based on limited data, and values are often adjusted with uncertainty factors to account for extrapolation across dose (LOAEL to NOAEL) or duration (acute to chronic).	Likely to overestimate in most cases	Unknown, could be significant
	Dose-response curves and toxicity benchmarks based on laboratory studies are assumed to be applicable to free-living populations in the field.	Unknown; variability maybe higher in wild populations than laboratory animals, hence high end risks may tend to be underestimated	Unknown, probably minor
Risk Characterization	Interactions between chemicals are difficult to account for; effects of one chemical may increase, decrease, or have no effect on other chemicals.	Unknown	Unknown, but probably small
	Estimation of population-level effects from HQ calculations is difficult and subject to professional judgement.	Unknown	Unknown, probably small in most cases